

ne basis as each of you was paid at the of March." (Se Approved For Release 2008/01/03 : CIA-RDP91B00135R000601140023-6 without pay in March and middle managers had received half pay; the rest of the employees received full pay.) But in mid-April, the company filed a report with the SEC stating that it was "unable to pay all of its suppliers and creditors on a current basis." And then on 30 April—"Black Friday," as some employees are calling it—Lilly and Kilgore informed the staff in a memo that there was not enough cash on hand to pay them. Kilgore left the building before the memo was distributed and installed a dead-bolt lock on the door to the offices.

The final straw occurred when the Internal Revenue Service demanded payment of \$60,000 by 1 May, a claim that the memo said was an "unforeseen negative thing" that "jeopardized our cash."

The memo gave employees the option

of staying away from work in May "in which your job having expired," or of reporting to work in the hopes that sufficient cash would become available to pay salaries. If not, the employees would be paid in stock, the memo said. Most of the scientists decided to take the first option and look for other jobs.

Several of the company's directors have also recently bailed out. The first to go was Marc H. Bozeman, a Los Angeles attorney and former director of compliance for the FDA's Bureau of Biologics. Bozeman, who is still handling Southern Biotech's legal matters with the FDA, resigned as director on 1 April, citing the company's inability to obtain satisfactory coverage for insuring officers and directors against liability as a reason for his departure. He was followed later in April by E. C. Watkins, one of the company's founders, and Robert Brackett, vice president for regu-

latory affairs, who had joined last September. He is still a director in mid-May, and he told *Science* that he knew virtually nothing of the company's financial affairs.

Southern Biotech is thus faced with mounting bills, it has a promissory note to Key Energy Enterprises for nearly \$1 million due in August, most of its scientific staff has left, and it still has no market for its stockpile of interferon.

Its extraordinarily swift rise and fall says a lot about the financial climate surrounding biotechnology in the past few years. Its impending collapse is likely to make the climate more hostile, however. Other companies now seeking capital will not find their task made any easier by Southern Biotech's performance. Potential investors in biotechnology should now be looking for something more than overblown promises when they decide where to put their money.

—COLIN NORMAN and ELIOT MARSHALL

Laser Wars on Capitol Hill

The House has invoked the laws of physics in a budget battle with the Senate over the best way to build space lasers

A strange and otherworldly force has intruded upon mundane politics in the nation's capital.

The laws of physics have been invoked in a battle between the House and the Senate over how the United States should build space lasers. A triumph of scientific reasoning could touch off an abrupt about-face in the U.S. laser program, which to date has consumed more than \$2 billion in pursuit of long wavelength lasers that look increasingly useless. A more attractive candidate is the short wavelength laser. Alternatively, a continuation of the current program could result in the development of lasers that emphasize bravado and political muscle rather than technical excellence and the ability to slice through metal in real conflicts.

So far, the defense contractors behind the status quo seem in a position to prevail.

The House touched off the battle when it said the Administration's \$156 million program in fiscal 1983 for the development of space lasers could result in a technical fiasco. From an evaluation of elemental physics, the House Armed Services Committee said the long wave-

length chemical lasers currently under development by the U.S. military will be extremely difficult to convert into useful weapons and will pose hardly any threat to the Soviet military or other enemies in space. "It is the committee's judgment that emphasis is being focused on the wrong laser technology," said an April report on the Defense Authorization Act. The current effort should be scrapped, according to the committee, and in its place studies should be initiated on short wavelength lasers, which are more lethal.

On the other hand, the Senate says such a move would delay the launch of a U.S. space laser until late in the next decade. The current long-wave lasers are perfectly adequate, says the Senate, and, unless the current program moves forward vigorously, the United States will lose the race for the domination of space to the Soviets.

The war of words is currently in a deadlock. The Senate recently passed its defense authorization bill and backed the status quo. The House will not vote on its bill until sometime in mid-June. Differences in the bills will be ironed out in conference.

The Pentagon's current effort, pioneered by the Defense Advanced Research Projects Agency (DARPA), centers on chemical lasers. These produce coherent rays in the infrared portion of the electromagnetic spectrum (at about 2.7 microns). They work something like rocket engines, using hydrogen and fluorine as fuel. DARPA programs include one named Alpha, which is aimed at producing a hydrogen-fluoride laser capable of radiating 5 megawatts; Lode, which is to produce a 4-meter mirror for aiming laser beams; and a program called Talon Gold, which is to demonstrate the tracking of targets in space.

The nub of the House's argument is founded on physics. The shorter wavelength lasers it favors, operating at or near the visible part of the spectrum, could achieve the military goals of the program much more efficiently than long wavelength chemical lasers, which are fairly easy to defeat by having a target covered with special coatings or polished so it reflects much of the laser beam. The first consideration in favor of shorter wavelengths is that the optics in general are easier to make. With wavelengths 6 times shorter than the ones currently

envisioned, the mirror could be 6 times smaller. (Optical tolerances, however, have to be more precise.) Also, a shorter wavelength means the power of the laser is focused into a smaller space, increasing its lethality. With a wavelength 6 times shorter, the diameter of a beam hitting a target will be 6 times smaller, the area 36 times smaller, and thus the overall flux per unit of target area 36 times greater. The alternative, generating 36 times more radiation from the laser device itself, is a prodigious undertaking that taxes the imagination. In addition, shorter wavelengths put more energy into targets. For a missile body struck by a long wavelength laser, about 99 percent of the energy is reflected. With shorter wavelengths, the figure is about 90 percent.

The push for short wavelength lasers is not confined to the House. Last year, the Defense Science Board recommended that the Pentagon switch its emphasis to shorter wavelengths. The director of DARPA, Robert Cooper, after conducting a review of all the agency's laser programs, told the House Armed Services Committee in March that shorter wavelengths are more efficient. Air Force Deputy Chief of Staff for Research Kelly Burke also agreed that program emphasis should be on shorter wavelengths.

In its April report, the House Armed

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or calling for a cut of \$121 million from the Administration's fiscal 1983 budget request for space lasers, including the termination of two of the three principal long wavelength laser demonstration programs, Alpha and Lode. In place of these projects, the committee called for a \$50-million program to explore short wavelength lasers.

In particular, the House committee encouraged the exploration of the free-electron laser (FEL), which is based on technology similar to that of particle accelerators.

Critics of the move have one main objection. The short wavelength idea has not been seriously explored amid the rush to exploit lasers, and the technology is in a rudimentary state. Senator Malcolm Wallop (R-Wyo.), an advocate of space lasers, asked from the Senate floor, should we wait "to build the infrared lasers we know how to build, and instead put our money on the short wavelength lasers we do not yet know how to build? We have heard this sort of thing before. . . . Because we have listened, we have slipped behind in quantity and quality of strategic weapons. . . . We are faced with two sharply contrasting sets of claims in this field. The bureaucracy's claims which are reflected in the [House] Armed Services Committee's report, and my claims, backed by

is in the field: the aerospace industry."

After Wallop's pitch, the Senate passed an amendment to the defense authorization bill calling for a demonstration space laser, preferably within the decade.

Despite the Senate's disdain for the short wavelength option, work on the idea has forged ahead under conditions of less than lavish funding. A working FEL has been built at Stanford University in California, and state-of-the-art data are being collected at the Los Alamos National Laboratory in New Mexico. A good test-bed for a large FEL, according to short wavelength advocates, would be the huge Advanced Technology Accelerator now under construction at Lawrence Livermore National Laboratory in California.

The battle over how to build a proper laser for fighting a war in space offers an interesting window into the process of government. A new idea and an impressive consensus on how to go about the job have emerged, yet the great momentum behind existing laser projects, on which defense contractors have already spent millions, threatens to thwart a more rational approach. The result could well be laser battle stations that cost billions and look impressive but offer little by way of a credible threat.

—WILLIAM J. BROAD

Reagan Proposes to Restructure Soviet Forces

Ironically, both sides might be more vulnerable under Reagan's arms control plan

President Reagan achieved political success with his recent proposal to negotiate reductions in U.S. and Soviet nuclear weapons, even if his formula for reductions fell flat. A week after Reagan's announcement, Soviet President Leonid Brezhnev indirectly rejected the formula by faulting it as prejudicial to the security of the Soviet Union and a cover for a continued U.S. military buildup. A group of congressmen and arms control experts within the United States claimed that it might endanger the security of both countries, and worsen international tensions. But the President received high praise nonetheless, simply for agreeing at long last to talk with the Soviets about nuclear weapons and to listen to any Soviet counterproposals.

Although a date has not yet been set, negotiations are now expected to begin in late summer at the Soviet mission and the Botanic Building in Geneva, the historic location of previous negotiations and the ongoing U.S.-Soviet talks about weapons in Europe. These talks have bogged down in large part because of U.S. insistence on its opening proposal, but this tactic will not be used during the discussions about strategic nuclear weapons. Administration officials admit that Reagan's formula is merely an opening gambit, and that it will inevitably be amended as negotiations proceed.

In hearings before the Senate Foreign Relations Committee, Secretary of State Alexander Haig acknowledged that the proposal imposes the heaviest burden on

the Soviet Union, because it focuses on the weapons that form the bulk of the Soviet arsenal: land-based missiles. The proposal asks that the Soviets eliminate—over a period of years—the majority of its land-based missiles, destroying in the process about 3000 warheads. In compensation, the Soviets could increase the number of warheads on submarines by about one-third. The United States, in contrast, could increase the total number of warheads atop land-based missiles by 500, although it would have to cut the number of warheads aboard submarines in half.

The overall purpose of these cuts, Reagan says, is to reduce the total number of nuclear weapons in the world, as well as to restructure the Soviet's arse-

Nuclear Power for Militarization of Space

The Department of Defense eyes nuclear reactors as a powerhouse for such projects as laser battle stations and radars the size of a football field

Orbiting laser battle stations and other military satellites will require more power than can be easily generated by large arrays of solar panels. The militarization of space may therefore require the development of nuclear reactors, smaller than a compact car, that generate as much electricity in space as small cities use on Earth. All it takes is time, muscle, and money.

That was the message heard recently at the National Academy of Sciences. The symposium—attended by some 250 contractors, bureaucrats, physicists, and members of the military—aimed at stimulating discussion on how to construct reactors that might fit into the cargo bay of the space shuttle. The aim would be nuclear power for laser weapons, particle beams, large surveillance satellites, and deep-space missions. Such symposia may become more frequent, judging from the upbeat tone of the proceedings. Federal funding for the development of space reactors now stands at about \$10 million a year. According to several speakers at the meeting, however, the cost of a development program leading to a working reactor might run to billions of dollars.

Not surprisingly, a bureaucratic tug of war between the departments of Defense and Energy has been provoked by the allure of big money for space reactors. Although the Department of Energy (DOE) has a long track record in reactors, energy officials fear the military is attempting a takeover. The symposium itself was funded almost entirely by the military.*

On the sidelines of the turf war is the U.S. nuclear power industry, which is closely watching the action. It apparently hopes that nuclear projects in space may compensate for a slump in nuclear sales on Earth.

The force behind the symposium was the Pentagon's drive for new missions and arms, though only a glimpse of futur-

istic weapons could be caught by the public. Eleven of the 28 presentations were classified. These 11 closed sessions, moreover, were the only ones that dealt with missions, as distinct from open sessions on reactors. Hints on the nature of the missions were laced throughout the public sessions, however. Examples were laser weapons and particle beams. Another example mentioned in public was a space-based radar 71 meters in diameter. Such a large antenna could distinguish very small objects. Said Robert V. Anderson of Rockwell International during his discussion of radar: "It doesn't take much imagination to see the possibilities."

Most satellites in orbit now require less than a kilowatt of electric power. In contrast, the large radar would require at least 50 kilowatts. Although speakers at the symposium discussed designs for reactors of 100 megawatts (enough to power the city of Hartford, Connecticut), the current goal is a multimission reactor of 100 kilowatts. According to some speakers at the meeting, it could be ready for launch in the space shuttle before the end of the decade.

A look at the long quest for nuclear power in space—a goal pursued by both East and West for decades—suggests that the task of developing small reactors will not be altogether easy.

Repeatedly used in space missions for several decades, the most elementary form of nuclear power has come not from a reactor but a device known as a Radioisotope Thermoelectric Generator (RTG). With this, the natural decay of plutonium releases heat that is converted into electricity. Rather than heating water or some other fluid that rotates a generator, the heat of an RTG is turned directly into electricity by strips of heat-sensitive metal known as thermoelectric generators. RTG's put out 60 to 75 watts for U.S. moon landings and Pioneer and Viking space probes. Ones generating 300 to 400 watts were used on Voyager and will be on Galileo and Solar Polar missions. Though mostly shot into space by the National Aeronautics and Space Administration (NASA), the devices have been designed and built by DOE. Perhaps the greatest notoriety for an

RTG went to one that never left the Earth. It was lost during a blizzard atop Nanda Devi, one of India's highest peaks. The nuclear-powered spy device was to be used by the U.S. government for monitoring atomic tests in China (*Science*, 15 June 1979, p. 1180). The failed mission was first revealed in 1978 and raised fears in India that radioactive runoff would pollute the Ganges.

For decades, the military's pursuit of high-powered missions has created a desire for better conversion efficiencies than the 5 to 10 percent offered by RTG's. Reactors, operating at temperatures of 1000 to 2500 degrees Kelvin, pack more punch. They also are much hotter and often more complicated than RTG's or conventional reactors, requiring pumps, turbines, and plumbing made out of special alloys that can withstand high temperatures.

The nub of the reactor problem is how to transfer tremendous heat. Reactors, in fact, are classed according to the substance used to carry heat from the radioactive core to an exchanger where it is converted into electricity. High-temperature reactors use liquid metals such as sodium, which are corrosive but carry much more heat than water. Domestic reactors, operating at lower temperatures, typically rely on water for heat transfer.

The Atomic Energy Commission (AEC) in 1955 began to study solid-core fission reactors for the production of electricity in space, a program known as Space Nuclear Auxiliary Power (SNAP). The initial aim was 50 kilowatts. Many reactors were built, but only one made it into space. This was SNAP-10A, a fairly low-temperature device that was fueled by uranium and cooled by a mix of liquid sodium and potassium pumped in a closed cycle. Its aim, considerably scaled back from the original, was to generate 500 watts of power. On 3 April 1965 an Atlas-Agena rocket at Vandenberg Air Force Base shot the reactor into a near-circular polar orbit of 13,000 kilometers. The reactor worked flawlessly for 43 days and then failed. (It still orbits and will reenter the atmosphere some 4000 years hence, after it has lost most of its radioactivity.) A twin reactor

*Symposium on Advanced Compact Reactor Systems. Committee on Advanced Nuclear Systems, National Research Council, Washington, D.C., 15 to 17 November. The symposium was funded by the Defense Advanced Research Projects Agency, the National Aeronautics and Space Administration, the Air Force Office of Scientific Research, the Air Force Aeropropulsion Laboratory, the Naval Air Systems Command, and the Army Mobility Equipment R & D Command.

currently undergoing design studies at Los Alamos. The reactor Approved For Release 2008/01/03 : CIA-RDP91B00135R000601140023-6 uranium oxide. Its unique feature is that the fluid (lithium) that transfers heat to thermoelectric generators is carried not by a complex web of plumbing and turbines but by devices known as heat pipes. These carry heat without the aid of moving parts and thus with less chance of a breakdown, a big help in space. The hot fluid flows down a pipe to the electric generators and then returns to the reactor via a wick in the center of the pipe. To date, 2-meter pipes have been tested. The SP-100 design calls for 120 pipes, each 9 meters long. The reactor core itself, minus pipes and shielding and thermoelectric generators, is about the size of a bread box.

The Soviets have lofted nuclear reactors into space for several years, a fact that became quite evident in 1978 when radioactive pieces of Cosmos 954 fell on Canada (*Science*, 16 February 1979, p. 632). Early Soviet reactors were known as Romashka, and a later generation as Topaz. The designs are unique. With Topaz, the Soviets rely on thermionic converters, known as diodes, right in the core of the reactor. This eliminates the need for complex plumbing or heat pipes. It also ensures a short lifetime for the reactors, because of intense heat and radiation. Topaz reactors are often used to power ocean-surveillance radars. According to Rockwell official Anderson, the Soviets launched four such radars during the past year.

One dream of American military planners is to have space-based radars that are bigger and better, and would last longer, than the Soviet ones now patrolling the oceans. Such nuclear-powered radars could cut through clouds and monitor sea traffic, and possibly help trace the deep movements of submarines. They also could have a role in target acquisition on land, working on a much grander scale the kind of electronic magic recently performed by Israeli Hawkeye radar planes flying in the Middle East on combat missions.

The dream could become a reality by around 1990, according to one military estimate. The radar could be powered by the SP-100 reactor. A bit further down the line are nuclear-powered battle stations, devices that would require megawatts instead of kilowatts. Vast amounts of electricity would especially be needed for the short-wavelength lasers that have recently taken a prominent place on the Pentagon's wish list (*Science*, 4 June, p. 1082). Unlike long-wavelength lasers, whose beams are often powered by chemical reactions, short-wavelength

devices such as free electron lasers use frequency generators and large electromagnets. The same holds true of weapons that shoot beams of subatomic particles.

Since military reactors would be operating in a hostile environment (some firing at enemy battle stations), "it will be necessary to design a system that can withstand some damage," William A. Ranken of Los Alamos told the symposium. These reactors also must be able to maneuver rapidly in space. "People ask me if I can design a power plant that can withstand 1, 2, or 3 times the acceleration of gravity, and the answer is yes; 10g is another story," said Ranken.

The political fallout from the Cosmos

"It would be appropriate to keep the leadership in civilian hands."

crash in Canada was a fair amount of public concern. (President Carter, for one, pledged that the United States would pursue a ban on nuclear power in space. Subsequently, the United Nations approved guidelines for such projects, and the United States abandoned its position.) So, too, public fear might arise in the future, especially with the possibility of nuclear battle stations blasting away at each other and raining radioactive debris down on Earth. The symposium addressed the questions of safety and regulation, although mostly in the context of peacetime missions.

"None of the 23 nuclear power systems used thus far to supply electricity or heat for space missions has been subject to licensing," L. Manning Muntzing, a Washington, D.C., lawyer and president of the American Nuclear Society, told the symposium. Muntzing said the systems have been considered research devices, and therefore exempt from licensing due to a provision of the Atomic Energy Act. However, as the space nuclear enterprise grows older and standardized reactors and RTG's are more and more frequently shot into space, some form of regulation will be necessary. Rather than tossing the problem in the lap of the Nuclear Regulatory Commission, Muntzing suggested an independent agency, which might be named the Space Nuclear Power Systems Safety Board. "Establishment of such a board," he remarked, "can have benefits not only on the plane of reality, but—as can sometimes be almost as important in the field of public regulation—

on the plane of appearances as well. lic perception that when program sponsors are evaluating risks, technological enthusiasm can overwhelm prudence." He left open the question of whether the findings of the board should be binding, or merely advisory.

Despite the distant nature of a large program for the development of space reactors, the bureaucratic battles are now being waged in earnest. Politicking over turf was clearly evident at the symposium, where Gordon L. Chipman, Deputy Assistant Secretary of Energy, took pains to emphasize in his presentation that "We have been charged with the responsibility of space reactor development and we have had years of experience."

Fighting the Department of Energy for control of the program is the Defense Advanced Research Projects Agency. DARPA, which allied itself with NASA in the turf war, requested bids in December for a 100 kilowatt space reactor from contractors across the country, the goal being power for reconnaissance satellites. DARPA, according to energy officials, is also trying to exert control over DOE programs. DARPA's inroads may well be illegal, due to the separation provisions of the Atomic Energy Act. Said Muntzing in an interview after the symposium: "As I understand the philosophy that has been used from the beginning, it would be appropriate to keep the leadership in civilian hands."

Whether the militarization of space will be aided by the development of small reactors is ultimately a question of policy for which there is currently no clear guidance. Proponents say nuclear technology has evolved remarkably. Materials science has yielded insights, and new approaches, such as heat pipes, have opened completely new avenues. Most important, proponents say there are now clear reasons, mostly military, for the pursuit of nuclear power in space. On the other hand, there are technical risks, public fears, and the long history of project failures. Perhaps the most important question is whether the superpowers really need to embark on a race to build a nuclear-powered battlefield in space. The military and technological pressure is obviously there. But so is the possibility of bilateral negotiations that would limit nuclear power to peaceful projects such as engines for deep-space missions of exploration. The issues are potentially controversial, and the debate, in Congress and other forums, will undoubtedly be lively.

—WILLIAM J. BROAD

Fallout from Nuclear Power in Space

The Defense Department's plan to build a new generation of compact nuclear reactors to power laser battle stations and other military satellites (*Science*, 17 December, p. 1199) has an ominous history. In 1964, a U.S. nuclear-powered satellite burned up on reentry and contaminated the atmosphere with plutonium. Unlike the breakup of a Soviet nuclear satellite over Canada in 1978, the U.S. accident received almost no publicity at the time. Moreover, a recent military-sponsored symposium on space nuclear power made no mention of the accident and its fallout.

The incident began on 21 April 1964 when a Transit navigational satellite was launched from Vandenberg Air Force Base in California. On board was a power supply known as SNAP-9A, a radioisotope thermoelectric generator that was fueled with about 1 kilogram of plutonium-238. The rocket's engines failed in mid-flight, and the satellite and its lethal payload came crashing back into the atmosphere over the Indian Ocean.

Plutonium is one of the world's most toxic metals. Its radioactivity shows up in bones and lungs.

In 1964, search teams using sophisticated air sampling techniques

combed the crash site and subsequently decided the satellite had completely burned up during reentry and that the plutonium had dispersed as a fine dust in the atmosphere (*Science*, 10 November 1967, p. 769). Over the years, the plutonium slowly worked its way down to the surface of the earth, mostly in the Southern Hemisphere. By 1970 about 95 percent of the SNAP plutonium had settled out of the atmosphere. The contamination was not unprecedented but it was quite large. During the days of atmospheric nuclear testing, some plutonium had spread throughout the atmosphere. In contrast, the U.S. satellite fiasco was estimated to have resulted in a three-fold increase of plutonium-238 contamination (*Nature*, 16 February 1973, p. 444).

The possible health effects of the accident have not been studied in depth. But a 1974 report (WASH-1359) by the now-defunct Atomic Energy Commission (AEC), which managed the space reactor program, said they appeared to be minor.

After the SNAP-9A accident, two other misfortunes befell the U.S. space nuclear power program. In neither case was plutonium released into the atmosphere. The first occurred in May 1968 when a Nimbus weather satellite failed to achieve orbit and plunged into the Santa Barbara Channel off California. Its plutonium power pack, known as SNAP-19, was recovered intact. The final accident occurred in April 1970 when the Apollo 13 moon-landing mission was aborted because of an onboard fire. The command module and the three astronauts were successfully picked up. The lunar lander, however, plunged to the floor of the Pacific Ocean and could not be found. It is estimated that its plutonium fuel pack, known as SNAP-27, will remain intact for about 860 years.—WILLIAM J. BROAD

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p. C1 col. 3.

Despite Dangers of Nuclear Satellites, Their Allure Persists for Superpowers

ALTHOUGH the Soviet satellite Cosmos 1402 fell harmlessly over the Indian Ocean on Sunday, it did so only after it frightened much of the world for weeks with the specter of radioactive debris raining down on earth. No one doubts the potential for harm posed by nuclear reactors in orbit.

But despite the danger, both superpowers have shot nuclear reactors into space — the Russians with relative frequency — and both are tinkering with new types of reactors. The Soviet Union has launched 18 nuclear-powered spy satellites. The United States in 1965 launched one reactor, which still circles the earth, and the Defense Department is currently considering a return to the business of boosting reactors into orbit.

Why all the interest? The main reason is that reactors can generate much more power than the usual arrays of solar panels, paving the way for supersatellites. Spy missions such as Cosmos 1402 use radars that consume large amounts of electricity. For fighting space wars, the United States is considering the construction of laser battle stations that would require as much electricity in space as small cities use on earth.

"In the past there were no urgent missions and so the space reactor program died," says Dr. Gary Bennett, a physicist in the special reactors branch of the Department of Energy. "But now the military is starting to show interest."

Reactors are seductive because the main alternatives,

solar cells, pack hardly any punch at all. Solar arrays on orbiting satellites often put out less than a kilowatt of power, barely enough to warm up a toaster and crisp an English muffin. In contrast, Soviet spy satellites that circle the earth with cloud-piercing radar, including the ill-fated Cosmos 1402, reportedly consume about 20 kilowatts.

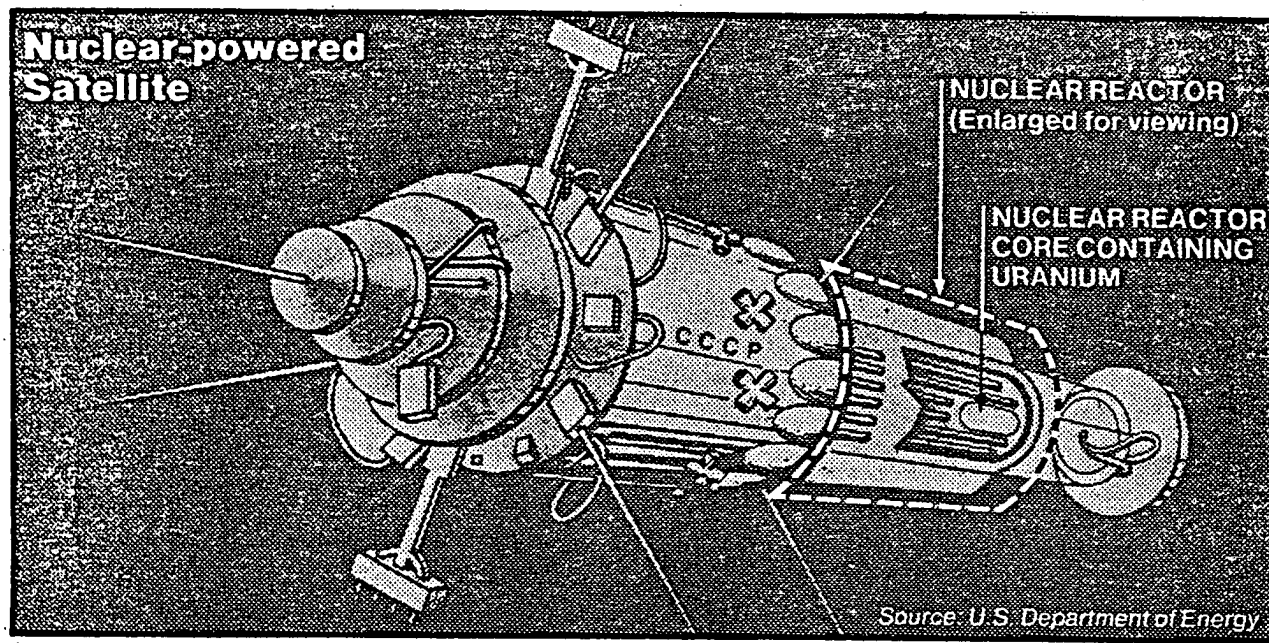
Large solar arrays can be constructed for such missions, but they are expensive and heavy. According to Dr. David Burden, a physicist at the Los Alamos National Laboratory in New Mexico, a solar array and batteries for a large radar in space would weigh about twice as much as a nuclear reactor.

The direction of the American nuclear quest was recently sketched out at a symposium on space reactors, financed mainly by the military and held at the National Academy of Sciences. Currently on the drawing board is a space radar, with a circular antenna 230 feet in diameter, that would require about 50 kilowatts.

To power this and other supersatellites, the effort of the United States now aims at developing a multimission reactor of 100 kilowatts that would fit into the cargo bay of the space shuttle. The reactor is under study at Los Alamos. Its core, minus pipes and shielding and electric converters, is about the size of a basketball. Other scientists are studying space reactors of 100 megawatts, enough to power the city of Hartford.

Potential civilian uses of nuclear power in space include

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The New York Times/Jan. 25, 1963

Artist's conception of Soviet nuclear-powered satellite similar to one that came down over the Indian Ocean.

Superpowers' Big Plans for

Continued From Page C1

direct television broadcasts, manned missions to distant planets, and the generation of power for cities on earth.

Yet current enthusiasm is fueled mainly by military missions, according to scientists in and out of the Government. Nuclear-powered satellites, freed from the delicate bulk of solar panels, are compact and thus considered more durable amid space war. They make small targets. Moreover, with their ability to generate huge amounts of electricity, they might be able to jam enemy communications over wide areas of the earth, pick up faint signals from clandestine transmitters the size of a ballpoint pen and track submarines deep in the ocean with powerful blue-green lasers. Large nuclear-powered radars in space could pinpoint the worldwide movement of planes and ships. Laser battle stations, their beams flashing out at the speed of light, might shoot down enemy missiles.

Federal financing for the development of space reactors now stands at about \$10 million a year. At the recent symposium, some speakers envisioned a program that would run to billions of dollars. The Soviet Union spent from \$14 billion to \$28 billion in 1980 for all space projects, according to a recent report of the Senate Commerce Committee. The figure is well above the total 1980 American space budget of \$9 billion.

The United States poured billions of dollars in the 1950's and 1960's into the development of nuclear power for space. The focus of the program was engines for missiles and rockets.

Power of Hoover Dam

The challenge was summed up by Dr. Glenn T. Seaborg, then chairman of the Atomic Energy Commission: "What we are attempting to make is a flyable compact reactor, not much bigger than an office desk, that will produce the power of Hoover Dam from a cold start in a matter of minutes." Despite success with prototypes, a nuclear-powered rocket never got off the ground.

What did shoot into space was something more modest, a reactor for satellites. In April 1965, a conventional rocket at Vandenberg Air Force Base launched the reactor into a near-circular polar orbit of 8,000 miles. It worked flawlessly for 43 days and then failed after an error by a ground controller. One of the experiments on board was an ion engine, something the National Aeronautics and Space Administration today is still considering for deep-space missions. The reactor circles the earth and is expected to re-enter the atmosphere in 4,000

Nuclear Satellites

years, after most of its radioactivity has decayed.

In the absence of missions and Governmental support, the United States program died in the early 1970's.

There were also technical hurdles. Today the development of nuclear power for space would be easier because of new techniques and materials, according to American physicists. In particular, Los Alamos scientists are working on heat pipes, which eliminate the need for pumps and moving parts in the transfer of heat to power generators.

Strong objections to nuclear satellites come from such critics as the

Progressive Space Forum in Washington. Space, the critics say, should not be an arena for war — and thus should not require high-power reactors. For peace, they say, solar cells would suffice for most missions and what is needed is not new technology but a negotiated ban on nuclear power in space.

Proponents retort that nuclear reactors in space are lighter, more compact and less expensive than large solar arrays, even for peaceful missions of relatively high power, such as voyages to distant planets.

William J. Broad

THE NEW YORK TIMES, TUESDAY, JANUARY 23, 1983

p. 3 col. 1

U.S. Scans Indian Ocean for Radiation

By JOHN NOBLE WILFORD

Special to The New York Times

WASHINGTON, Jan. 24 — United States aircraft and ships patrolled the Indian Ocean today to check for any increased atmospheric radiation from the nuclear-powered Soviet satellite's fiery plunge back to the earth.

The Defense Department here said it had no reports yet on the survey results. Nor did it have any new information on whether any fragments of the four-ton craft survived the re-entry yesterday and reached the water. The "impact area" was so far from land, the Pentagon said, that the satellite's final plunge could not be observed.

Meanwhile, the North American Aerospace Defense Command turned its attention to tracking the remaining segment of Cosmos 1402, which Soviet officials have said is the nuclear fuel core. This smaller section, probably weighing less than 1,000 pounds, could enter the atmosphere as early as next week.

According to the command's calculations, the fuel-core section is cir-

cling the earth in an orbit ranging from a high of 132 miles to a low of 127 miles. As with the rest of the Cosmos, the section is travelling each day over all parts of the world between 65 degrees north latitude and 65 degrees south. American tracking analysts have not released any new re-entry time predictions since the one they made last week, which established a "re-entry window" of Feb. 7-13.

The Soviet Union yesterday forecast that the fragment including the fuel core of the satellite's reactor should enter the dense layers of the atmosphere between Feb. 3 and Feb. 8. The Soviet statement continued to emphasize that the core would disintegrate and burn up well before it reached the surface.

Earlier Soviet statements also said that the "radiation situation will be within the limits recommended by the International Commission on Radiological Protection," a United Nations body that studied the issue.

Pentagon officials have generally agreed with the Soviet assurances, noting that in a somewhat similar incident in 1978, the uranium fuel of Cosmos 954 apparently burned up completely high in the atmosphere. But some fragments of the satellite's

structure did survive and fall over the sparsely populated Northwest Territories of Canada.

Although the American and Soviet Governments issued several seemingly conflicting statements on Cosmos 1402 in the last three weeks, there was a tendency now among American officials to accept Soviet predictions. After all, a Soviet statement Friday night was remarkably accurate in forecasting not only the time but the general area where the main body of the satellite would fall. It predicted the satellite would come down late Sunday over the "region of the Arabian Sea."

The satellite, in fact, plunged through the lower, dense atmosphere soon after it passed over the Arabian Sea, coming down far south of the Indian subcontinent.

Maj. Douglas Kennett, a Pentagon spokesman, said that American space experts were not too surprised by the Soviet accuracy. "It's their satellite," he said. "They knew the satellite's characteristics, which we didn't know. They have an excellent tracking system. They ought to be able to predict that."

Geoffrey Perry of Kettering, England, an amateur space tracker with

considerable experience in the field, called the prediction "amazing," adding, "I compliment them on their estimate."

The main body of Cosmos 1402 had been tumbling and apparently out of control since Dec. 28. A Soviet attempt to boost the reactor section, including the fuel core, into a higher, safe orbit had failed.

Although satellites or pieces of satellites fall out of orbit every week, nearly all of them disintegrate and burn from the friction of their passage through the atmosphere, posing no danger below. It is not known how many fragments ever survive the re-entry. So many of the objects fall into the ocean or on unpopulated lands and are never seen, as in the case of Cosmos 1402 yesterday.

Concern over the satellite was heightened, however, because it carried a nuclear reactor and some radioactive pieces of a satellite like it, Cosmos 954, had survived the re-entry in 1978 and come down on land.

Major Kennett, the chief Pentagon spokesman for the Cosmos watch, said, "I don't think we'll ever know if any of this Cosmos reached land. That sort of material would be sitting now on the bottom of the Indian Ocean."

FUEL OF SATELLITE FALLS 'HARMLESSLY'

it Experts Debate Long-Term Effect of Radioactive Cloud

By WILLIAM J. BROAD

The last fragments of Cosmos 1402, launched in a fiery plunge over the North Atlantic Ocean 1,100 miles east of New York yesterday. Scientists are divided over whether health hazards have been created by the radioactivity released behind in the upper atmosphere, a short time after re-entry, which occurred about 6:10 A.M. New York time, Pentagon spokesman said the 110-pound enriched-uranium core had apparently "burned harmlessly."

This final piece of the satellite to fall after caused as much worry as the debris section that fell on Jan. 23, and its demise came about more or less as predicted.

The Pentagon said reconnaissance planes would check the atmosphere in the South Atlantic for any signs of increased levels of radioactivity. The debris broke up at 19 degrees south latitude, 22 degrees east longitude.

Radioactive Dust in Atmosphere Despite an apparent end to the drama, which began in late December as a vain Soviet attempt to send the nuclear reactor into a higher orbit, it was to remain for 500 years, the core has not "burned up" but has been taken down into a cloud of radioactive dust.

Experts are unable to agree on whether the radioactive cloud poses a hazard to human health. One school holds there is no health risk. Another says that statistical analyses suggest that the radioactivity added to that already in the atmosphere will be carried by winds around the globe, eventually

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resulting in a few additional cases of genetic damage and death from cancer. Moreover, since both the United States and the Soviet Union plan to send other nuclear-powered satellites into space, some groups say the health question may arise again in more dramatic form.

In contrast, Government scientists, while acknowledging past problems with the launching and use of American and Soviet nuclear-powered satellites, are becoming safer with each passing year. Cosmos 1402 is one of eight nuclear craft that have plunged to earth unexpectedly. In 1969, according to the Department of Energy, two Soviet moon-bound craft "burned out in the atmosphere with the detected release of high-altitude radiation." One predecessor of Cosmos 1402 plunged into the Pacific Ocean north of Japan in 1973, and another fell over Canada in 1978.

Accidents have also struck the

American program. In 1964, a Transit nuclear-powered satellite failed to achieve orbit and broke up over the Indian Ocean. In 1968, a similar fate befell a Nimbus satellite. A final nuclear accident occurred in 1970 when the Apollo 13 moon lander plunged into the Pacific Ocean.

While Soviet failures center on nuclear reactors, the American ones have been with radio-isotope thermoelectric generators, devices that put out power through the natural decay of plutonium.

The first American accident touched off an attempt to limit the dangers. Transit's power pack spread 17,000 curies of plutonium 238 throughout the atmosphere. To avert the problem, subsequent power packs were wrapped in a thick metal shield that would stand up to the heat of atmospheric friction. The solution worked well in the next two accidents, according to Dr. Gary L. Bennett of the Energy Department. The power pack from the Nimbus satellite was recovered intact from the Santa Barbara

Last of Cosmos 1402 Disperses Over Ocean

channel off California, and the one from Apollo 13 today rests unopened in Tonga Trench of the Pacific.

Yet unacceptable dangers still remained, according to the General Accounting Office. In 1977 it found that "emphasis on meeting time schedules and the intense interest in promoting the use of nuclear power in space have resulted in launches of nuclear-powered satellites despite unresolved questions of nuclear safety."

Critics such as the Progressive Space Forum say that the relative luck of both the United States and the Soviet Union cannot last much longer. "Both countries are going in the direction of greater reliance on space nuclear power," said John Pike, a member of the Forum's national board, "and the accidents are likely to increase."

The gamble for the American program could be quite great, according to Mr. Pike. He said a Martin Marietta Corporation study of possible risks in launching a plutonium-powered satellite estimated that an acci-

dent could result in 40,000 fatal cases of lung cancer.

The Soviet Union, which has had its share of problems, has tried to avert catastrophe by redesigning space reactors. The crash of Cosmos 954 resulted in a 500-mile-long "footprint" of radioactive particles across the Canadian outback.

The best way to avoid the danger, according to scientists in both the East and the West, is either to boost reactors into orbits high enough so that deadly fission products will have decayed by the time of re-entry, or to build reactors so they totally disintegrate in the upper atmosphere. Shields are difficult to build because of pipes and control rods.

A radioactive dust cloud, according to Dr. David Buden of the Los Alamos National Laboratory, will eventually become quite dilute as it disperses in the atmosphere. "The success of the method can be seen in the absence of excessive exposure following the re-entry of Cosmos 954, when the reactor is thought to have had at least 500,000 curies of fission product activity at shutdown," he said.

With the failure of Cosmos 1402, the Soviet Union revealed a new precaution. According to Dr. Oleg M. Belotserkovsky, director of the Moscow Physico-Technical Institute: "The radioactive fission products from the reactor insure guaranteed conditions for it to burn up in the dense strata of the atmosphere and for the materials to be dispersed into finely divided particles."

The question is what happens to the radioactive dust. If it stays suspended in the upper atmosphere, it will eventually decay and become harmless. If, on the other hand, it soon drifts down to earth, entering the food chain and the lungs of humans, it might cause problems.

According to the Progressive Space Forum, the long-lasting fission products of Cosmos 1402 are cesium and strontium, up to 50 curies of each. By interpolating from the damaging effects of fallout in the test of atmospheric nuclear weapons, the group estimates that the radioactivity from Cosmos 1402 could eventually result in cases of genetic damage, and anywhere from one to three deaths from radiation-induced cancer. This is a best estimate, and assumes that radioactivity will be distributed uniformly rather than concentrated in some way.

The chief frustration in the fallout calculations is that there is no easy way to know who is right, no way to know if the particles hanging harmlessly in the atmosphere or enter the ecosystem and cause cancer. The problem was summed up by a Pentagon spokesman on the crash of Cosmos 1402: "There's no license plate on this stuff, so we don't know who causes the increase in radioactivity after while."

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